measurements on the NIST High Accuracy Cryogenic Radiometer [20]. The HACR is the U.S. primary standard for optical power. The scale of absolute spectral responsivity [21] is transferred by silicon photodiode trap detectors to working standards used with the NIST Visible to Near-Infrared [22] and Ultraviolet Spectral Comparator Facilities (hereafter referred to as the Vis/NIR SCF and UV SCF respectively in this document) where the Spectroradiometric Detector measurements are performed.

2. NIST Spectroradiometric Detector Measurement Service

This section describes the photodetector calibrations and measurements offered by the Optical Technology Division. A complete listing of the calibration services across all the measurement parameters offered by NIST can be found in the NIST Calibration Services Users Guide [23]. Current fees can be found in the Fee Schedule [24] which is updated annually and on the internet at the URL address: http://ts.nist.gov/ts/htdocs/230/233/233.htm.

2.1 Description of Measurement Services

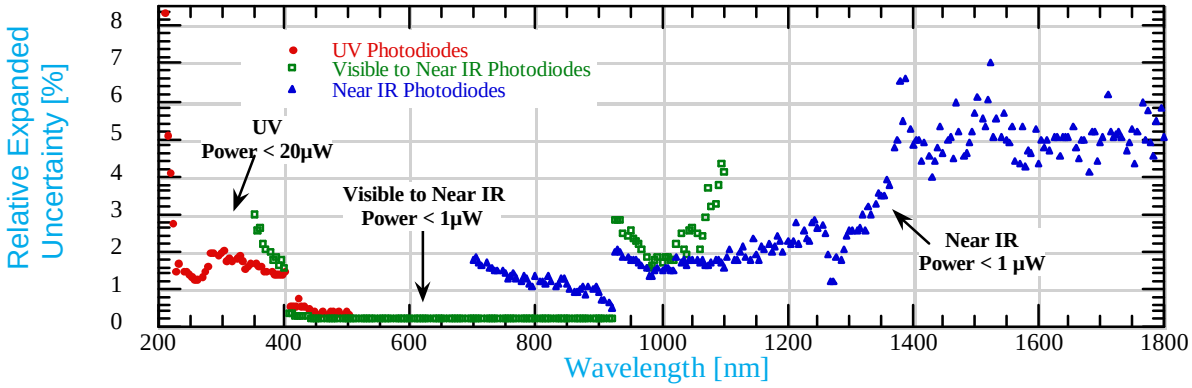
There are two types of measurement services provided by NIST: Fixed Services and Special Tests. Fixed services (Service ID numbers ending in the letter C) have fixed measurement conditions and NIST issues a calibration report to the customer. Special tests (Service ID numbers ending in the letter S) have no fixed measurement conditions; are services that are under development; and/or are for unique customer-supplied test items. Service ID numbers 39071S through 39075S are currently in the process of being converted from Special Tests to Fixed Services (i.e., calibrations).

The present spectral range for photodetector absolute spectral responsivity measurements are from 200 nm to 1800 nm. Table 2.1 lists the services offered with typical measurement ranges and typical uncertainties. All services listed are provided routinely. The relative expanded uncertainties of the Spectroradiometric Detector Measurement Service are shown in figure 2.1 and table 2.2. See section 7 for a detailed explanation of the uncertainties.

Table 2.1. NIST Spectroradiometric Detector Measurement Services

Service ID number	Item of test	Range	Relative expanded uncertainty ($k = 2$)
39071S	Ultraviolet Silicon Photodiodes (UDT UV100)	200 nm to 500 nm	0.4 % to 13 %
39072S	Retest of Ultraviolet Silicon Photodiodes (UDT UV100)	200 nm to 500 nm	0.4 % to 13 %
39073S	Visible to Near-Infrared Silicon Photodiodes (Hamamatsu S2281)	350 nm to 1100 nm Can be extended to 200 nm	0.2 % to 4 % 0.2 % to 13 %
39074S	Retest of Visible to Near-Infrared Silicon Photodiodes (Hamamatsu S1337-1010BQ or S2281)	350 nm to 1100 nm Can be extended to 200 nm	0.2 % to 4 % 0.2 % to 13 %
39075S	Special Tests of Near-Infrared Photodiodes	700 nm to 1800 nm	0.5 % to 7 %[†]
39080S	Special Tests of Radiometric Detectors	200 nm to 1800 nm	0.2 % to 13 %[†]
39081S	Special Tests of Photodetector Responsivity Spatial Uniformity	200 nm to 1800 nm	0.0024 % to 0.05 %[†]

[†]Depends on photodetector and signal level.



(Note: Relative expanded uncertainty at 200 nm is 13 %.)

Figure 2.1. NIST UV, visible, and near-IR spectral responsivity measurement uncertainties. The three curves are the relative expanded uncertainty ($k = 2$) for measurements with the three different working standard types.

Table 2.2. Detector Measurement Services Uncertainties

	Relative expanded uncertainty ($k = 2$) [%]			
Wavelength [nm]	UV100 (UV)	S1337 (Visible)	Ge (NIR)	InGaAs (NIR)
200	13.02			
250	1.36			
300	2.06			
350	1.68	2.96		
400	1.46	1.56		
450	0.38	0.24		
500	0.38	0.22		
550		0.20		
600		0.20		
650		0.20		
700		0.20	1.78	1.80
750		0.22	1.42	1.46
800		0.22	1.32	1.38
850		0.22	1.12	1.16
900		0.22	0.92	0.96
950		2.58	1.80	1.82
1000		1.72	1.50	1.52
1050		2.66	1.74	1.74
1100		4.16	1.56	1.56
1150			1.92	1.92
1200			2.26	2.26
1250			2.60	2.60
1300			2.56	2.56
1350			3.46	3.46
1400			4.80	4.80
1450			4.64	4.64
1500			5.66	5.66
1550			4.94	4.96
1600			4.30	4.34
1650			5.04	5.08
1700			4.92	5.04
1750			5.24	5.38
1800			5.02	5.36

Descriptions of each Service ID number are provided below.

39071S - UV Silicon Photodiodes

NIST will supply customers with a UDT Sensors, Inc. model UV100 windowed silicon photodiode characterized in the ultraviolet (UV) spectral region. The UV silicon photodiode includes the measured spectral responsivity [$A \cdot W^{-1}$][3] from 200 nm to 500 nm in 5 nm steps. The 1 cm^2 photosensitive area of the photodiodes is underfilled for the measurements with a beam of diameter 1.5 mm. The spectral responsivity is measured at radiant power levels of less than 20 µW. The bandpass of the measurement is 4 nm. The relative expanded uncertainty ranges from 0.4 % to 13 %, depending on the wavelength. The spatial uniformity of responsivity over the photosensitive area is also measured at 350 nm.

39072S - Retest of UV Silicon Photodiodes

Special tests of UV silicon photodiodes previously supplied by NIST (under 39071S) are performed by measuring spectral responsivity from 200 nm to 500 nm.

39073S - Visible to Near-Infrared Silicon Photodiodes

NIST will supply customers with a Hamamatsu model S2281 (previously a Hamamatsu S1337-1010BQ) windowed silicon photodiode characterized in the visible to near-IR spectral region. The spectral responsivity of the photodiode is measured from 350 nm to 1100 nm in 5 nm steps. The 1 cm^2 photosensitive area of the photodiodes is underfilled for the measurements with a beam of diameter 1.1 mm. The spectral responsivity is measured at radiant power levels of less than 1 µW. The bandpass of the measurement is 4 nm. The relative expanded uncertainty ranges from 0.2 % to 4 %, depending on the wavelength. The spectral range can be extended to 200 nm with a relative expanded uncertainty from 0.2 % to 13 % for an additional fee. The spatial uniformity of responsivity over the photosensitive area is also measured at 500 nm.

39074S - Retest of Visible to Near-Infrared Silicon Photodiodes

Special tests of visible to near-infrared silicon photodiodes previously supplied by NIST (under 39073S) are performed by measuring spectral responsivity from 350 nm to 1100 nm. The spectral range can be extended to 200 nm for an additional fee.

39075S - Special Tests of Near-Infrared Photodiodes

Special tests of customer-supplied near-infrared photodiodes are performed by measuring spectral responsivity from 700 nm to 1800 nm. A beam of diameter 1.1 mm is centered on and underfills the photosensitive area. The spectral responsivity is measured at radiant power levels of less than 1 µW. The bandpass of the measurement is 4 nm. The relative expanded uncertainty ranges from 0.5 % to 7 % or greater, depending on the wavelength and the individual item measured. Customers should communicate with one of the technical contacts listed in section 2.4 to discuss details before submitting a formal request.

[3] For clarity, the coherent SI unit is given in brackets for many quantities used in this publication. Of course, SI multiples and submultiples of these units may also be used.

39080S - Special Tests of Radiometric Detectors

Special tests of radiometric detectors in the ultraviolet, visible, and near-infrared regions of the spectrum can be performed. Detector characteristics that can be determined in this special test include spectral responsivity and quantum efficiency (electrons per photon). For example detector responsivity can be measured between 200 nm and 1800 nm at power levels less than 4.0 µW. The relative expanded uncertainty ranges from 0.2 % to 13 % or greater, depending on the wavelength and the individual item measured. Since special tests of this type are unique, details of the tests should be discussed with one of the technical contacts listed in section 2.4 before submitting a formal request.

39081S - Special Tests of Photodetector Responsivity Spatial Uniformity

Special tests consisting of measuring the relative changes in responsivity across the photosensitive area (spatial uniformity) can be performed for customer-supplied photodetectors. The uniformity is typically measured at a single wavelength in 0.5 mm spatial increments with a beam diameter of 1.5 mm in the 200 nm to 400 nm spectral region at power levels less than 20 µW, and a beam of diameter 1.1 mm in the 400 nm to 1800 nm spectral region at power levels less than 1 µW. The relative expanded uncertainty ranges from 0.0024 % to 0.05 % or greater, depending on the wavelength and the individual item measured. Customers should communicate with one of the technical contacts listed in section 2.4 to discuss details before submitting a formal request.

2.2 Measurement Limitations

There are a few limitations on the types of photodetectors that can be measured. Because of the beam size of the comparators, the detector's active area must be greater than 3 mm in diameter. Due to the monochromator flux level an amplifier gain of 10^5 to 10^7 is typically required, thus the photodiode dynamic impedance (shunt resistance) must be greater than 10 kΩ.

Physical size and weight are limited by the translation stages used in the UV SCF and Vis/NIR SCF. Detector packages submitted for testing are limited in size to approximately 20 cm by 20 cm by 20 cm and 2 kg.

Special tests with conditions greatly differing from those listed above may be accepted, but will take longer to complete. The photodetector signal (either voltage or current) must be provided via a BNC connector. Computer communication to a customer's detector package is not possible at this time.

2.3 How To Order Photodiodes Or Special Tests

1) Reference the Service ID number(s) on the purchase order.

   Details of Service ID numbers 39075S, 39080S, and 39081S should be discussed with one of the technical contacts listed in section 2.4 prior to submitting a formal request.

2) The purchase order should be sent to:

National Institute of Standards and Technology
Calibration Program
Building 820, Room 232
Gaithersburg, MD USA 20899-0001

Phone number:	(301) 975-2002
FAX Number:	(301) 869-3548
E-mail:	calibrations@nist.gov
Internet URL:	http://ts.nist.gov/ts/htdocs/230/233/233.htm

3) The purchase order must include the following:

A) Bill to address.
B) Ship to address (for the test detector(s) return delivery).
C) Method of return shipment (the costs below do not include shipping costs). If nothing is stated, NIST will return by common carrier, collect, and uninsured.
D) User's name, address (for test report), and phone number.
E) Service ID number(s).

4) The cost for special tests is based on the actual labor and material costs involved and customers are responsible for all shipping costs.

2.4 Technical Contacts

For technical information or questions contact:

Thomas Larason	(301) 975-2334	email: thomas.larason@nist.gov
Sally Bruce	(301) 975-2323	email: sally.bruce@nist.gov
or fax	(301) 869-5700	

Technical information can also be found at the following Internet URL:

http://physics.nist.gov/Divisions/Div844/facilities/phdet/phdet.html

All test detector(s) should be shipped to the following address:

Sally Bruce
NIST
Building 221 / Room B208
Gaithersburg, MD USA 20899-0001